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Transforming the World With Information Technology

Dr. Robert Atkinson
President
Information Technology and Innovation Foundation
ITIF is a public policy think tank committed to articulating and advancing a pro-productivity, pro-innovation and pro-technology public policy agenda internationally, in Washington and in the states. ITIF focuses on:

- Innovation processes, policy and metrics
- E-commerce, e-government, e-voting, e-health
- Broadband and telecommunications
- IT and economic productivity
- Innovation and trade policy
The Digital Information Revolution
Better Tools
Drive
Progress
IT Tools Are Today’s Engine of Growth and Transformation
Why is IT Driving Change?

- IT is what economists call a “general purpose technology” (GPT).
“General Purpose Technologies” Drive Transformation

- Most innovations come incrementally, with modest changes in products, processes and business models.

- But approximately every half century a new technology *system* emerges that changes everything.
  - Steam power
  - The Railroad
  - Electricity
  - Steel
“General Purpose Technologies” Drive Transformation

- These new technology *systems* impact virtually everything:
  - what we produce,
  - how we produce it,
  - how we organize and manage production,
  - the location of productive activity,
  - the infrastructure needed, and
  - the laws and regulations required.

- Since the mid-1990s IT has been the engine of change.
“General Purpose Technologies” Go Through Phases

- When the GPT begins life, it is usually in a crude form that is only slowly improved and adapted.

- Later in its evolution, when it is becoming well developed, its efficiency rises quickly.

- Eventually physical limits are approached, causing gains in efficiency to slow, and finally come to a halt if the GPT remains in use long enough.
**GPT Drivers During Periods of American and European Economic History**

<table>
<thead>
<tr>
<th>Period</th>
<th>Years</th>
<th>Technology System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercantile/craft</td>
<td>1840s to 1890s</td>
<td>Iron, Steam</td>
</tr>
<tr>
<td>Factory-based industrial</td>
<td>1890s to 1940s</td>
<td>Steel</td>
</tr>
<tr>
<td>Mass-production, corporate</td>
<td>1940s to 1990s</td>
<td>Electro-mechanical, chemicals</td>
</tr>
<tr>
<td>Entrepreneurial, knowledge-based</td>
<td>1990s to ??</td>
<td>IT</td>
</tr>
</tbody>
</table>
Technology Transformations Drive Growth

Old Electro-Mechanical Technology System

New IT System

1945-58  59-74  74-93  94-2000  2001-?-??  ??
The core technologies (memory, processors, storage, sensors, displays, and communication) continue to get better, faster, cheaper, and easier to use, enabling new applications to be introduced on a regular basis.

Many sectors have barely tapped the potential of e-transformation.

Application use is growing by business and consumers, and has not yet near completely matured.
GPT’s Have 4 Main Characteristics

1. They undergo rapid price declines and performance improvements.
Moore’s Law Has Not Slowed Down

Transistor Growth in Intel Computer Processor Chips

THE INFORMATION TECHNOLOGY & INNOVATION FOUNDATION
As a Result, Computing Power is Almost Free

- Microsoft’s Hotmail service provides subscribers 5 GB of free storage.
- Using 1975 technology would cost $100 million per user.
- Using 1995 technology would cost $5,500 per user.

(Intel processing costs, $ per MIPS)
## IT Doubling (or Halving) Times

<table>
<thead>
<tr>
<th>Category</th>
<th>Doubling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total bits shipped</td>
<td>1.1 years</td>
</tr>
<tr>
<td>Microprocessor Cost per Transistor Cycle</td>
<td>1.1 years</td>
</tr>
<tr>
<td>Magnetic Data Storage</td>
<td>1.3 years</td>
</tr>
<tr>
<td>Dynamic Random Access Memory (RAM) (bits per dollar)</td>
<td>1.5 years</td>
</tr>
<tr>
<td>Average Transistor Price</td>
<td>1.6 years</td>
</tr>
<tr>
<td>Processor Performance in MIPS</td>
<td>1.8 years</td>
</tr>
<tr>
<td>Modem Speeds</td>
<td>1.9 years</td>
</tr>
<tr>
<td>Transistors in Intel Microprocessors</td>
<td>2.0 years</td>
</tr>
<tr>
<td>Microprocessor Clock Speed</td>
<td>2.7 years</td>
</tr>
</tbody>
</table>
GPT’s Have 4 Main Characteristics

1. They undergo rapid price declines and performance improvements.

2. They are pervasive and a part of most industries, products and functions.
IT Used to be Scarce
Now IT is Everywhere
It’s Even in “Old Economy” Machines
(70% of computer chips don’t go into computers)

John Deere CEO Bob Lane says he doesn’t make tractors but rather “sophisticated mobile information factories.”

- GPS shows where it is
- Microwave sensors measure cotton flow
- RFID tags let processors know origin of each bundle
- Wireless communications
- Computing power of 8 PC’s
Server Farms and Computers are the New Industrial Complex

2004 U.S. investment in new factories = $16.3 Billion

"U.S. Birthrate' For New Factories is Steadily Falling, WSJ, 3/15/06

2004 U.S. investment in IT = $1.1 Trillion

(vs.)
GPT’s Have 4 Main Characteristics

1. They undergo rapid price declines and performance improvements.

2. They are pervasive and a part of most industries, products and functions.

3. They enable innovation in products, processes, business models and business organization.
IT Enables New Business and Government Models

- Many of the best business models shift the boundaries of which party does which tasks. This boundary shifting is usually based on new possibilities created by IT systems.

- In one study, 32 percent of EU companies reported innovations, with IT enabling half of the product innovations and 75 percent of the process innovations.
IT Enables New Business and Government Models

- **Business models**: Wal-Mart’s supply chain; Amazon’s “long tail”; iTunes and the decline of bricks and mortar music stores; etc.

- **Processes**: self-service; mass customization; supply-chain integration; collaborative design; etc.

- **Products/Services**: hybrid cars; transportation telematics; human genome; etc.
Mass Customization is Replacing Mass Production

IT enables much of the economy to be more customized:

- Dell’s "build-to-order" model.
- Architectural Skylight Company uses CAD to automate the production of windows to architects' specifications.
- “Pandora” lets users create their own web-radio station.
The Digital Information Revolution

Giving us a vast array of choice:

- Products: Amazon.com
- Music: Internet radio, iTunes
- Video: YouTube, NetFlix
- E-learning: Free MIT courses; iTunes University; distance learning
- Personals: Match.com, JDate.com, PlanetEarthSingles.com
GPT’s Have 4 Main Characteristics

1. They undergo rapid price declines and performance improvements.

2. They are pervasive and a part of most industries, products and functions.

3. They enable innovation in products, processes, business models and business organization.

4. They drive productivity growth and profitability.
Computers, lasers, satellites, fiber optics, the Internet and a few other related communication technologies are driving economic growth.

It is an economy-wide process not located in just one hi-tech sector, any more than the New Economy initiated by electricity was confined to the electricity generating sector.

IT has outsized impacts:

- In large U.S. firms, every dollar of IT capital is associated with $25 of market value (Gao and Hitt, 2004).
- IT workers contribute significantly more to productivity than non-IT workers and the difference has grown over time (Tambe and Hitt, 2008).
- IT has 3 times more impact on productivity than non-IT capital (Nathan Associates, 2007).
IT Drives Productivity Growth

- IT was responsible for virtually all of the increase in U.S. labor productivity from 1995 to 2002.

- Dutch firms that invested more in IT not only enjoyed faster productivity growth but also produced more innovations (Van Leeuwen and van der Wiel, 2004).

- While France, Germany, the Netherlands, and the UK saw lower acceleration of productivity growth in intensive IT-using sectors than the U.S., the sectors still experienced increased growth.
Where is the IT Revolution Taking Us?
The Emerging Digital Transition: The World Becomes Alive With Information

- Phase 1: Mainframes: 1950s-1970s
The Emerging Digital Transition: The World Becomes Alive With Information

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- Phase 2: PC – Client Server: 1980s to mid-90s
- Phase 3: Networked Devices: 1995 to 2008
- Phase 4: Intelligent World: 2008 to ?
The World Is Becoming Alive With Information

- We are moving from an “information desert” where information is hard to collect, especially in real time; difficult to transmit; and challenging to make sense of…
The World Is Becoming Alive With Information

- to an “information rain forest” where information is all around us, easy to transmit, and simple to make sense of.
To More Than Facebook, Twitter, and YouTube
To An Emerging Intelligent World

- “Things” generate data (a societal “embedded nervous system”)
Trends: An IP address for every device: *IPV6 can provide multiple IP addresses to every grain of sand on the planet*
The Emerging Intelligent World

- An increasing share of information will be in machine readable, interoperable form.

- E-tickets
- E-cash
- E-forms
- E-banking
- E-bill presentment
The Emerging Intelligent World

- An increasing share of interactions will no longer be face-to-face, in person, but digital.
Digital Service

- Kiosks (airports, hotels, hospitals, retail, restaurants)
- Continued growth of web channel
- Voice recognition (e.g., medical transcription)
- Smart cards and mobile payments
- Robotics
The Emerging Intelligent World

- Software will bring intelligence to data (data mining).

**Sorting out the needles from the haystacks:**

- Data mining for homeland security
- Rapid learning health networks (e.g., Cancer Biomedical Grid)
- Foldit
The Emerging Intelligent World

- Data and Intelligence Will be In Real Time:
  - Traffic, weather & breaking news
  - Travel updates & local events
  - Pollution monitoring
  - Pandemic outbreaks
  - Tsunami warning systems and other oceanographic data
  - Blood glucose level in diabetic patient
  - Economic activity
The Emerging Intelligent World

- Data and Intelligence Will be In Real Place:
  - Home monitoring
  - Web-cams in daycare
  - GPS-enabled cell phones
  - Environmental sensors in the home
  - Intel’s “magic carpet” helps predict and detect falls
The Emerging Intelligent World

- “Tools” will be intelligent:
  - Vehicle-Infrastructure Integration
  - “Smart” products
  - Computer-assisted surgery
  - RFID-enabled tools
The Emerging Intelligent World

- Markets Will Emerge in Many More Areas:
  - RFID-enabled recycling bins
  - Pay by the mile vehicles using GPS
  - Smart meters
  - Online Auctions
  - Monster.com
The Emerging Intelligent World

- Accessible anywhere from any device.
The New Intelligent Revolution is Nearly Invisible
Unintelligent City
Intelligent City
Pessimists: The technologies have plateaued and all the gains that can be had have been had, meaning that productivity and innovation will slow to a crawl.
Hopefully, This Won’t Happen

Hello—we’re Luddites—and we’ve come to smash your new-fangled machine.
IT Trends: Pessimists, Optimists, or Pragmatists

- **Pessimists:** The technologies have plateaued and all the gains that can be had have been had, meaning that productivity and innovation will slow to a crawl.

- **Optimists:** Not only have we just begun to scratch the surface, but the rate of technological change is increasing, leading to revolutionary changes within our lifetimes.
Hans Moravec: *Robot*

- **2010**: robots with intelligence of a lizard (automatic lawn mowers)

- **2020**: robots with intelligence of a mouse (multi-function household robots, with arms and manipulators that might perform simple household chores)

- **2030**: robots with intelligence of a chimpanzee (general-purpose household robots)

- **2050**: robots equal human intelligence
In this new world, there will be no clear distinction between human and machine, real reality and virtual reality. In practical terms, human aging and illness will be reversed; pollution will be stopped; world hunger and poverty will be solved. Nanotechnology will make it possible to create virtually any physical product using inexpensive information processes and will ultimately turn even death into a soluble problem.
IT Trends: Pessimists, Optimists, or Pragmatists

- **Pessimists**: The technologies have plateaued and all the gains that can be had have been had, meaning that productivity and innovation will slow to a crawl.

- **Optimists**: Not only have we just begun to scratch the surface, but the rate of technological change is increasing, leading to revolutionary changes within our lifetimes.

- **Pragmatists**: Information technologies will continue to improve and adoption increase, but at some point both will plateau, at least until the next new technology system emerges.
The “S-curve” of Technology Transformations

- Electro-Mechanical System
- IT System

<table>
<thead>
<tr>
<th>Year</th>
<th>Takeoff</th>
<th>Installation</th>
<th>Slowdown</th>
<th>Takeoff</th>
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The “S-curve” of Technology Transformations

- IT System
  - Installation: 2001-2015
  - Slowdown: 2016-33
  - Takeoff: 2034-2040
  - Installation: 2041-2055
  - Slowdown: 2056-2070

- Nano-Bio System
Technology Opportunities

- Most electro-mechanical tech opportunities are taken.
- Nano’s opportunities are far in the future.
- IT opportunities are large and available now.
IT Transformation Challenges

- Industry resistance.
- Lack of universal facilitators (smart cards, digital signatures).
- Digital divide and slow adopters.
- Lagging sectors (e.g., health care, transportation, government, education).
- Slow high speed broadband roll out.
- Lack of standards (e.g., manufacturing, health care).
### Public Policy Principles for Driving Digital Prosperity

1. Look to digital progress as the key driver of improved quality of life and productivity.


3. Lead by example.

4. Support public-private partnerships to build digital platforms.

5. Support e-science and research into next generation IT.

   - Avoid regulatory restrictions (e.g. behavioral web targeting, net neutrality, etc.).
   - Protect intellectual property.
   - Reduce protections for incumbents against digital innovators.
Supporting Digital Platforms Will be Critical To Digital Transformation

- Platforms are shared technology systems that more than one firm uses.
  - Health IT
  - Smart Grid
  - Intelligent Transportation Systems
  - Broadband
  - GIS
  - E-Government
  - Etc.
Questions?

ratkinson@itif.org

www.itif.org